Volume 25 August, 1939 *Number 8*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Lubrication in the Production of Non-Ferrous Metals

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

BUNKER HILL AND SULLIVAN

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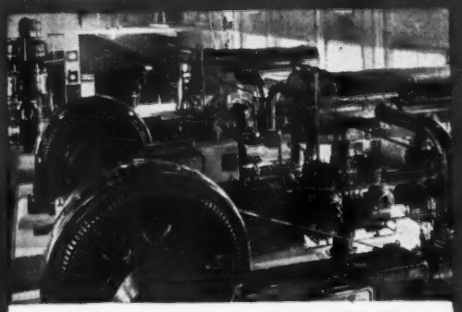
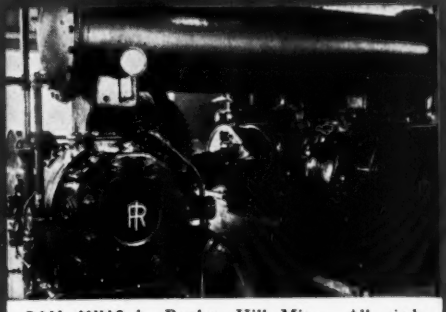
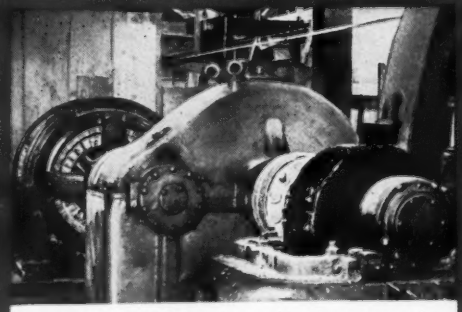


BURY Air Compressors in Bunker Hill Mines furnish air to underground drills, scraper hoists, loading machines.



BALL MILLS in Bunker Hill Mines. All girth gears are lubricated with Texaco Crater Compound. Texaco Ursa Oil in the speed reducers.



INGERSOLL-RAND 2-Stage Air Compressor in Bunker Hill-Sullivan's Crescent Mine. All compressors are lubricated with Texaco Algol Oil.

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LUBRICATION

A Technical Publication Devoted to the Selection and Use of Lubricants

Published by
The Texas Company, 135 East 42nd Street, New York City

Vol. XXV August, 1939 No. 8

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Lubrication in the Production of Non-Ferrous Metals

MINING and the refinement of copper, zinc, lead, nickel, and aluminum, five of the most widely used non-ferrous metals, present a number of problems to the lubricating engineer. They cannot be treated casually, nor should they be considered without deliberation, for the machinery involved is costly, subjected to heavy duty, and so correlated that failure of any part might seriously interfere with the production schedule.

The non-ferrous metals are required in virtually any type of machine design. In some combination or other, they are the basis of the sleeve-type bearing, the bronze in the worm reduction gear set, the mechanisms of the pressure lubrication system, the piping for lubricant transmission, or (as in the case of lead) as an additive to increase the film strength of lubricants. So these metals are of particular concern to the lubricating engineer, being assistants to lubrication. The operator, in turn, is interested, as he may have to prepare and pour bearing metals, decide upon lubricants most protective to bronzes, and evaluate the advantages of lubricating systems.

The machinery required to mine and refine these metals can be tabulated in a rather interesting manner, viz.:

Mine Compressors Rock Drills Scraper-Loaders Mine Cars Mine Locomotives Mine Hoists	copper, zinc, lead, nickel, aluminum
Power Shovels	copper and aluminum
Crushers Rolls and Grinders Conveyors and Filters Concentrators Flotation Equipment Classifiers	copper, zinc, lead, nickel
Casting Machines	copper, lead
Wire Rolls and Roll Necks Wire Spooling Machines	copper

MINING MACHINERY

In the mining of non-ferrous metals, the conventional rock drill is used for loosening the ore and drilling holes for explosives. Copper may be found as comparatively pure metal, or in the form of oxides, carbonates, or sulfides. Zinc, in turn, is found chiefly in the form of zinc sulfide (ZnS) or zinc carbonate ($ZnCO_3$); lead, principally as lead sulfide or galena (PbS); aluminum is mined almost universally as an oxide (Al_2O_3), by reason of its affinity for oxygen.

Copper ores may be very often surface mined or stripped from open cuts by power shovels as in Utah and Arizona, or shaft mined as in Montana. The others, however, are usually found some distance below the surface, so they must be shaft mined.

Ores which are surface mined are loaded

directly into ore cars for transportation to the concentrator. In shaft mining, on the other hand, after the ore has been broken away, it must be loaded onto mine cars and carried to the shaft hoist and thence to the smelter. Modern mining has become largely electrified, so we have air and electric power predominating below ground. The latter is extended above ground to power shovel operation, and to the manipulation of the various concentrating, smelting and refining machines.

AIR POWER

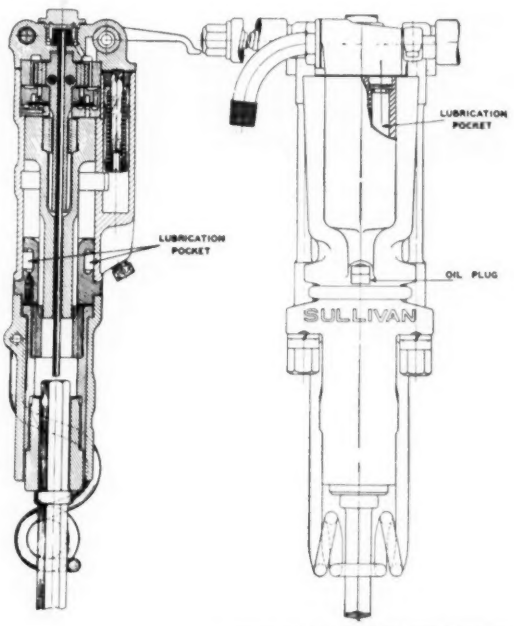
Air power as required for rock drill, scraper, loader and hoist operations must be developed by compressors. The mine compressor has been highly perfected over recent years. It is the most valuable auxiliary to below-ground operations, so it must function dependably, often at a widely-varying power rate. As lubrication is the best insurance of all this, it is well to analyse mine compressor lubrication requirements, and to realize that but a few dollars' worth of oil is relied upon to protect the investment of thousands, and a production schedule of inestimable value. Hence the best of lubrication is none too good in air power service.

Cylinder lubrication is most important. It must be maintained with the least amount of oil, yet this oil must function under temperature conditions which may be very severe. Cooling controls the temperature of the discharge air; during the peak of the compression stroke, however, considerable heat is developed. This is imparted to the oil film on the cylinder walls. A proportionate reduction in viscosity will result, with the possibility of carbon formation if the temperatures are high enough. As these are not sustained, however, if the intercoolers and after-coolers are working properly, breakdown of the oil will be a slow process. Modern methods of refinement produce petroleum lubricating oils which are highly resistant to heat, oxidation and breakdown.

Importance of Low Carbon Residue

The residual products of oil breakdown are, of course, carbonaceous. They will be fluffy, hard, brittle, or gummy, according to the degree of heat involved and the nature of the crude stock. A minimum of gummy residual matter is advantageous, as it is adhesive and carried away with difficulty by the air. Furthermore, any gummy residual matter will tend to pick up dust carried in by the air. Such accumulations are the chief cause of faulty valve action. Hence the advisability of using an air filter.

As the residual carbon residue content is indicated by the Conradson test in the United States and the Ramsbottom test in England and the British Empire, this has become one of the most important details in air compressor oil specifications. It should be as low as possible. It is practicable to obtain specially refined compressor oils within a 200 to 750 Saybolt



Courtesy of Sullivan Machinery Company

Fig. 1—The Sullivan Class L-9 rock drill showing points of lubrication.

Universal Viscosity range at 100 degrees Fahr., which will show a Conradson test below 0.10 per cent. Such oils are wholly distilled, filtered and pale in color.

The viscosity of a compressor oil must be chosen in accordance with the operating temperatures. This property is indicative of the relative fluidity of the oil at the specified temperature. It will change with change in temperature, heat causing the oil to become more fluid. So any film of compressor oil on the walls of an air compressor cylinder will be thinned down, for the heat of compression is considerable. Should the oil film become too thin, loss of compression may occur due to loss of seal. For normal mine compressor temperatures, it has been developed that a 300 viscosity oil (at 100 degrees Fahr.,) will give dependable service.

As lower viscosity oils will show lower Conradson carbon residue tests, one should never use any heavier oil than necessary. Nor should the rate of oil feed be too rapid. Probably two to three drops per minute per lubricator outlet will suffice, for we must remember that the oil will remain on the cylinder walls of an air compressor considerably longer than on the walls

of a steam or internal combustion engine, as little or no washing action or dilution of the oil will occur.

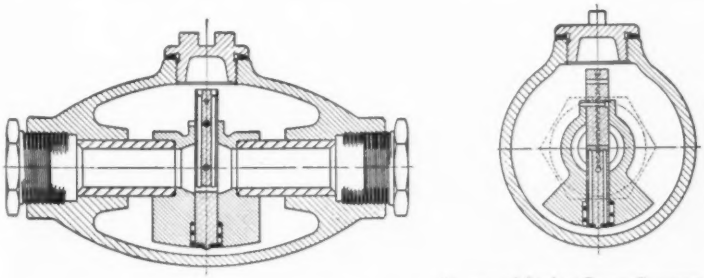
How to Judge Lubrication

The use of an unsuitable oil or an excess of the right oil will be indicated by ultimate carbonization in the air passages and particularly on the discharge valves. Dirty air will speed up these conditions materially. When the valves stick and hot compressed air passes back into the cylinder, it is high time to investigate the cause. An excellent procedure is to examine the discharge valves regularly, clean if necessary, and readjust the oil feed. Then blow out the coolers, receiver, and discharge piping to remove oil, water, or dirt accumulations. A slightly oily discharge valve is indication of adequate lubrication; too much oil anywhere in the system is indication of over-lubrication, and the lubricators should be checked accordingly.

DRILLING OPERATIONS

Air drill lubrication in mining operations requires careful consideration due to the fact that effective use of air has a direct relation to the power bill. In cold weather, the selection of suitable lubricants for drills and other types of air tools which may be exposed to the elements is especially important, for low temperatures increase the resistance to flow, thereby rendering petroleum lubricants more sluggish and less likely to reach all the mechanisms in certain types of tools. Hence the importance of low pour test and relative viscosity in predicting to what extent this may occur.

The modern rock drill operates by virtue of percussion or rapid hammering, constant pressure, or, in some cases, a combination of pressure and rotation. Where percussion is employed, air pressure acts on the tool mechanism in much the same manner as steam acts on the pistons of a steam engine. In other words, the tool mechanism involves a cylinder with suitable piston and valve arrangement for the admission of air at the proper time, according to the number of strokes per minute or percussive frequency required.



Courtesy of Gardner-Denver Company

Fig. 2—The Gardner-Denver air line oiler in longitudinal and transverse section. In this device the lubricant is atomized as it enters the air stream.

Methods of Lubrication

While the type and extent of refinement of the lubricants employed have much to do with efficient operation of any rock drill or pneumatic tool, the means whereby the former are admitted or distributed have a marked effect upon their ability to function effectively. Even the best of oils or greases may fail to do their work if they are used in such a manner as to be unable to reach all the wearing elements of the tools. Many authorities feel that probably more failures or complaints arise from ineffectual lubrication through misusage of lubricants, than from any average operating condition.

Air Line Oilers

Lubricators of this type are in general intended for the handling of fluid oils. They work on the principle of suction, atomization, or pulsation. In the suction type, the air in its passage through the working mechanisms, draws the requisite amount of oil from the reservoir by suction. Where atomization is involved, there is a needle or pin valve through which a certain amount of air passes to carry the required lubricant forward into the tool. In either case, air as it passes through the lubricator becomes charged with oil in finely atomized condition, to insure effective distribution to all parts of the tool with which it comes in contact.

The operation of a pulsation type lubricator is brought about by the reciprocating action of the piston, oil being kept thereby in continuous flow to the air and tool mechanisms. Such a lubricator is frequently built with an oil capacity sufficient to last over a working shift in order to reduce the possibility of lack of lubrication through negligence or carelessness on the part of the operators.

The Valve Chest Lubricator

This device operates by virtue of the pulsation of air in accordance with the movement of the tool piston within the cylinder. As a rule, such a lubricator is designed to handle heavier oils or light greases. Relubrication or recharging is accomplished by means of lubricant-carrying cartridges inserted into the lubricator.

Chuck Lubrication

Chuck lubrication can also be mechanically effected on many types of tools by attaching a suitable device near the front end adjacent to the chuck parts. In certain types of such lubricators, ports are provided for carrying the lubricant to the impact end of the piston and chuck mechanisms. Grease is usually preferred for the lubrication of such parts, a grade of medium bodied product being adaptable to average operating conditions. Obviously, it must be resistant to oil separation, and stable with respect to oxidation.

ORE GATHERING

Ore gathering is accomplished by the scraper-loader or the power shovel. As the latter was discussed only recently in LUBRICATION*, reference to that article is suggested. The scraper-loader, however, requires more active discussion.

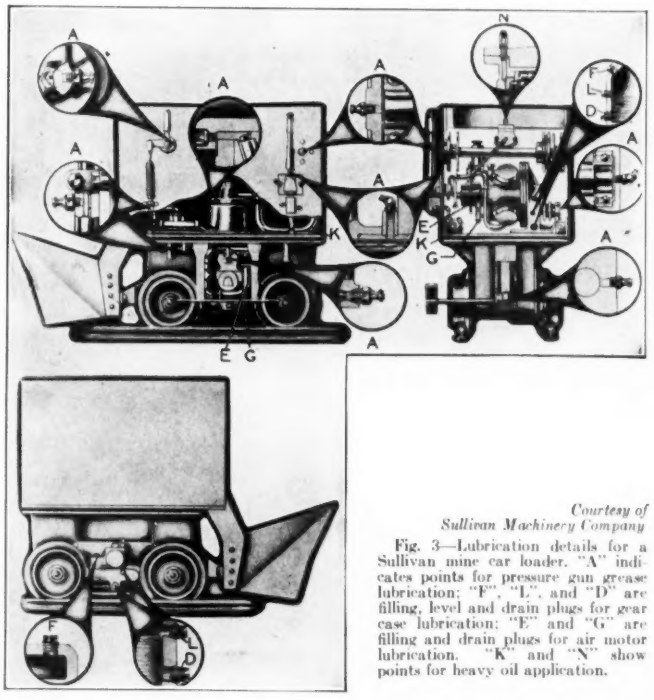
Loading Machinery

The modern ore loader is a gathering, conveying and materials handling device. The gathering or scraping mechanisms dig into the loosened material and drag it onto the conveying unit, which carries it to the mine cars.

Ore loading machinery must function in intimate contact with abrasive materials which promote wear. In consequence, lubrication must be given careful consideration, with due regard for the protection which proper choice of lubricants will insure. Gears, chains and bearings will be involved, according to the design of the machine. In addition, on certain loaders built for hydraulic operation, oil will be required in the hydraulic system. Such oil also serves to lubricate the interior parts.

Automatic lubrication has received very careful study in appreciation of the productive importance of the loading machine. Automatic lubrication may involve merely the lubrication of gearing and gear shaft bearings by splash from the oil in a reservoir which is formed by the gear case, or the use of some form of pressure lubrication, handling either grease or oil, according to requirements of the wearing elements and the manner of housing. It is advantageous in that it usually enables the lubricant to perform its intended function of reducing metallic friction and wear more effectively. Furthermore, it promotes economy of lubricants, for, as a general rule, lubricating systems will be of more nearly an oil-tight nature. Such construction has a further advantage in that it more completely prevents entry of mine waters or ore dust.

Oil or grease is used according to the design of the system. Where the operating mechanism



Courtesy of Sullivan Machinery Company

Fig. 3—Lubrication details for a Sullivan mine car loader. "A" indicates points for pressure gun grease lubrication; "F", "L", and "D" are filling, level and drain plugs for gear case lubrication; "E" and "G" are filling and drain plugs for air motor lubrication. "K" and "N" show points for heavy oil application.

can be served from a central reservoir, it will usually be advisable to use a relatively heavy bodied, straight mineral oil. Such a product will follow all gear and pinion teeth readily, will penetrate throughout all normal bearing clearance spaces, and will insure that chain roller or link mechanisms will receive an adequate amount of lubricant.

Grease of fairly low consistency can also be used in certain gear cases. In fact, this is the recommendation of some builders. Care should be taken, however, that any grease used is compounded with a high grade of low pour test, mineral oil; otherwise, should low temperature conditions prevail, as in surface mining, there will be possibility of congealment and lack of sufficient lubrication, especially if bearing clearances are comparatively low.

Where hydraulic operation of the gathering, shoveling or conveying elements is provided, a high grade machine or engine oil of light to medium viscosity should be used. Such a product, if of sufficiently low pour test, should function effectively and give adequate lubrication to all plunger rods, etc. The necessity for low pour test is to insure against the oil becoming so sluggish at low temperatures as to require

* January, 1939.

excessive power consumption in the operation of the plungers and connecting parts.

The exposed parts of the average ore loader, such as the chains, tractive elements, bearings, etc., which may require periodic hand lubrication can be served by machine oil of about 200 seconds Saybolt viscosity, or a medium consistency grease, according to the means provided for application. Exposed gears, in turn, require a straight mineral, semi-fluid lubricant. Such a product will insure adequate protection of gear teeth, with minimum loss through dripping or the action of centrifugal force.

MINE CARS AND HAULAGE EQUIPMENT

The efficiency of mine car and haulage equipment is largely controlled by the extent to which the wheel bearings can be kept properly lubricated. Four basic types of such bearings predominate, viz.:

Ball or roller bearings,
Cavity or self-oiling units,
The hollow axle bearing, and
The plain or sleeve type.

Ball and Roller Bearings

The use of ball or roller bearings is being widely extended in the modernization of many properties. Sealing against loss of lubricant or entry of contaminating foreign matter can be maintained, economy of lubricants is practicable, and the cost of maintenance is low.

The protective nature of the seals permits the use of high quality grease for lubrication. Normally a grease for ball bearings should be compounded with a fairly high viscosity straight mineral oil in order to obtain load carrying ability.

Soft or semi-fluid greases are best suited for roller bearings in mine car service. Where the latter are of solid, cylindrical or tapered construction, a somewhat more inert grease will be advisable than on hollow flexible bearings. It will be found that such a product will furnish a better cushion between the axle and rollers than a more liquid grease. Furthermore, it will also form a better seal against possible entry of dust, dirt or water, provided the bearing itself is equipped with a reasonably tight seal. Lubrication of flexible roller bearings, however, can be best accomplished with a semi-fluid or so-called liquid grease. The usual construction of such bearings provides for the hollow spaces within the rollers serving as grease reservoirs. In consequence, the lubricant must be sufficiently fluid to pass through and penetrate to all the surfaces of contact. It should never remain inert within the rollers, or tend to gum, otherwise protection of the bearings will be seriously impaired.

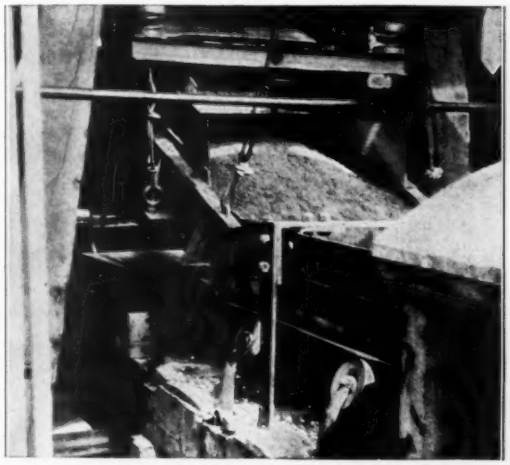
Cavity or Self-Oiling Wheels

The cavity type of mine car wheel is lubricated from an oil or grease reservoir around the hub. During rotation, the lubricant is fed to the axle or journal through port holes staggered in the hub. This occurs when the car is idle or running slowly. At higher speeds centrifugal force tends to carry the lubricant to the outer surface of the reservoir. For this reason, due to possibility of leakage, care should be observed in regard to the amount of lubricant used. In general, the lubricant level should be maintained on a line with the lower part of the axle when the car is at rest.

A highly refined straight mineral engine or car oil of medium to heavy viscosity will in general be best suited to the operating conditions, and will insure most complete protection of the bearings. Where service in cold weather is essential, it should be able to flow through the distributing ports readily. It is also perfectly practicable to use a comparatively light grease where there is possibility of oil leakage. To assure of fluidity in cold weather, a low pour test on the oil content is advantageous.

Hollow Axle Design

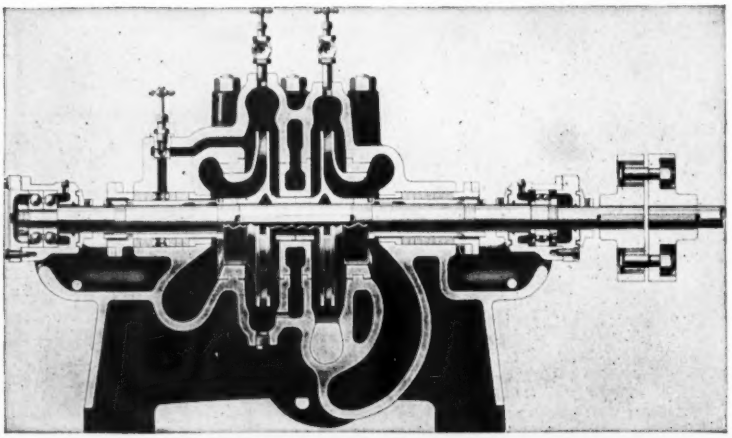
This type of construction involves hollow axles of tubular steel, the hole extending completely through the axle, which acts as a reservoir for lubricant. At the outer end of the axle, near each extremity is a flat valve seat and a spring loaded valve similar to an ordinary



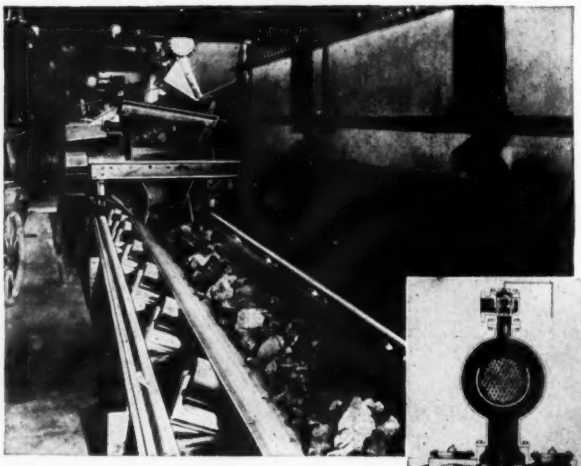
Courtesy of The Jeffrey Manufacturing Company

Fig. 4—A Jeffrey-Traylor electric vibrating feeder delivering damp concentrates to a belt conveyor.

check valve with the exception that the guide is several inches long. A spiral spring encircles the valve stem and compels the valve to maintain a bearing on the seat, thus preventing

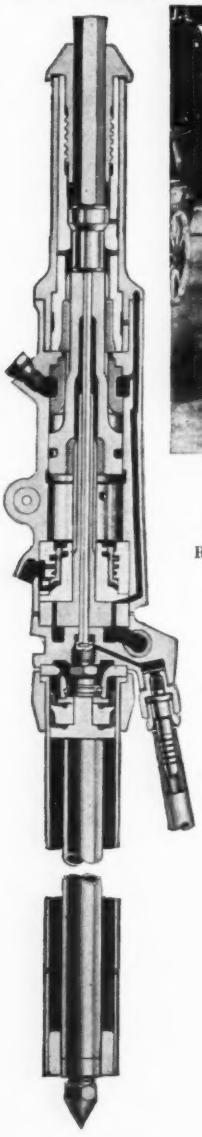


Courtesy of Ingersoll-Rand Company
(Top Left)—Details of a Cameron two-stage centrifugal mine pump.

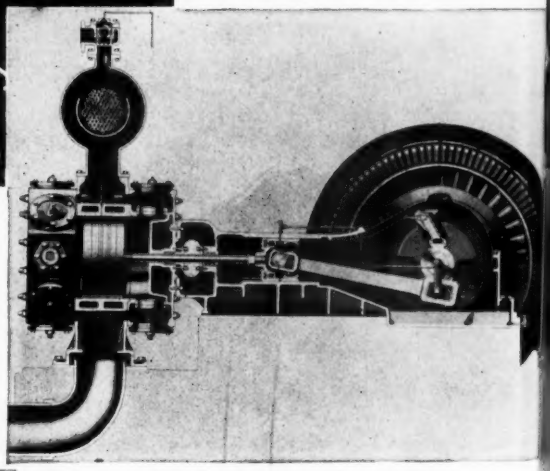


Courtesy of Link-Belt Company
(Lower Left)—Handling copper ore on a Link-Belt anti-friction belt conveyor.

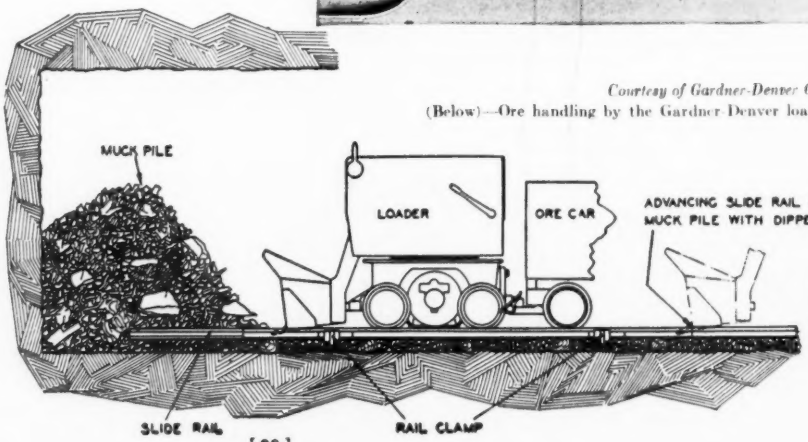
Courtesy of Ingersoll-Rand Company
(Center, Below)—Cross section showing lubricating system of a PRE compressor.

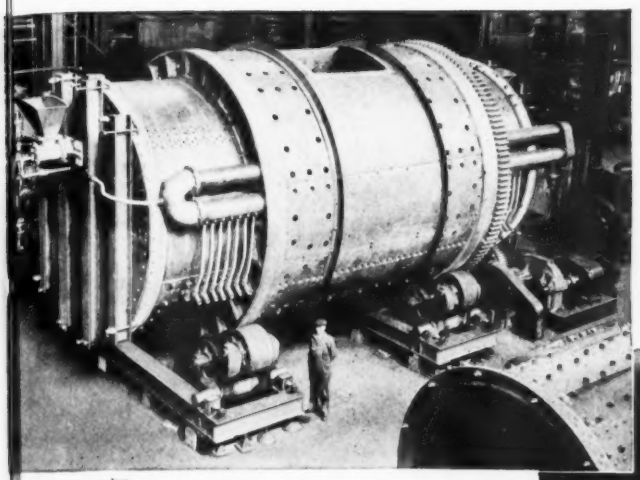


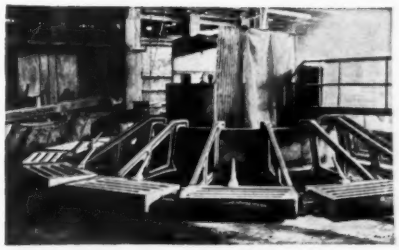
Courtesy of Gardner-Denver Company
(At Left)—Details of a Gardner-Denver R-104 Stoper.

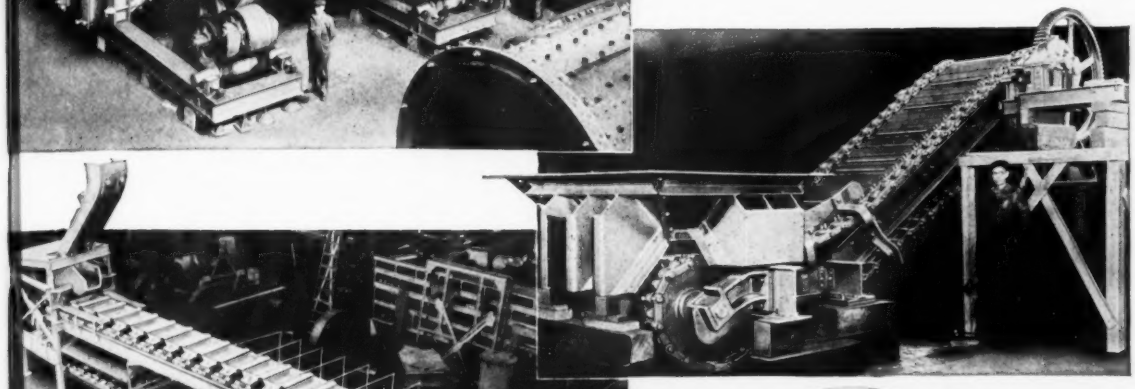


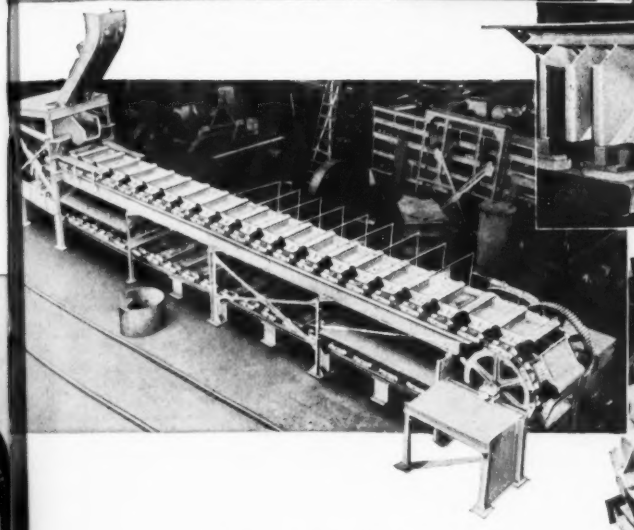
Courtesy of Gardner-Denver Compa
(Below)—Ore handling by the Gardner-Denver loader.

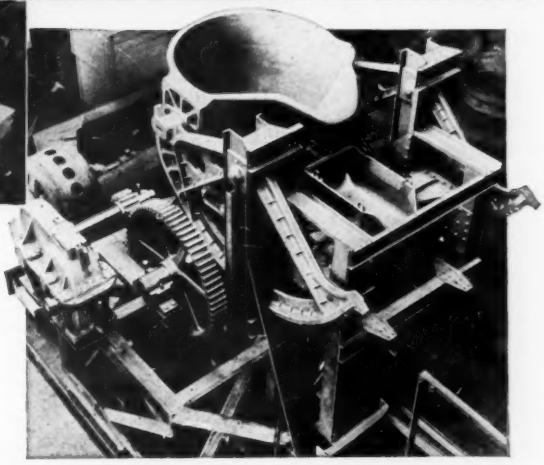










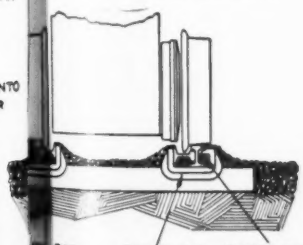


Courtesy of Allis-Chalmers Manufacturing Company

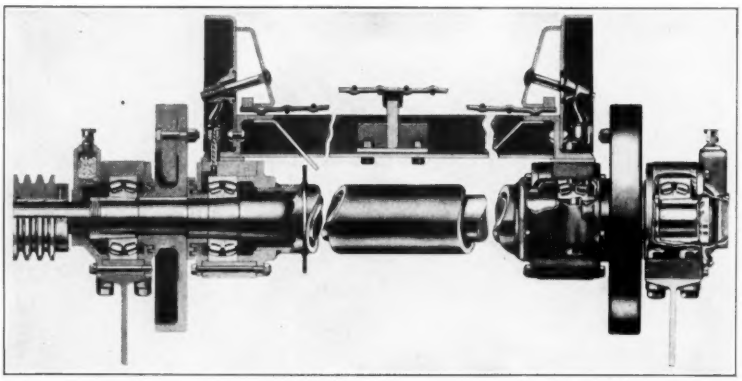
(Top Left)—A copper converter.
(Top Right)—A Walker type circular casting machine.
(Lower Left)—A straight line casting machine.
(Center Right)—A water bosch and conveyor.
(Lower Right)—A tipping device for the casting machine.

Courtesy of The Dorr Company, Inc.

(Extreme Lower Right)—A Dorr fine grinding and classification plant equipped for centralized pressure lubrication.



leakage of the lubricant from the axle. At the point on the axle corresponding to the bearing surface of the wheels, the axle tube is perforated sufficiently to permit passage of the lubricant from within the axle outward to the contact surface of the axle with the inner bushing of the wheel hub. In this way the lubricant is constantly working its way outward to maintain a protective film between the wearing parts, and when the proper type of grease is used there is assurance of minimum cost of maintenance and parts renewal.



Courtesy of Link-Belt Company

Fig. 5—Cross section through the vibrator mechanism of a Link-Belt heavy-duty positive drive vibrating screen showing oil cups for bearing lubrication.

Grease of comparatively low consistency or a medium-bodied oil can be used according to the design of the bearing. Normally where axle sealing valves function effectively, a charge of lubricant within the axle will suffice for from three to four months without renewal.

Sleeve Type Bearings

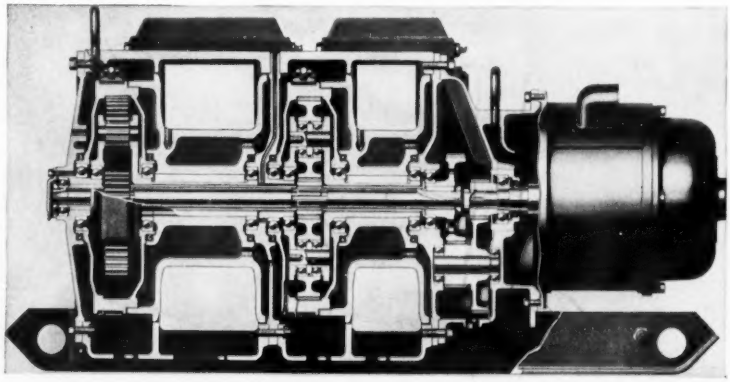
Such bearings are often so constructed as to enable the use of oil-saturated wool yarn or waste packing. Effective lubrication is assured by regular attention to loosening of the waste, or oil-carrying material and resaturating with a suitable grade of straight mineral bearing oil or a light grade of liquid grease. Matting or glazing of the oil-carrying materials is detrimental, for this will reduce the capillarity of the packing, and prevent the requisite amount of lubricant from being transmitted to the contact surface.

Mine Locomotive Gears

Locomotive gearing, in turn, requires the use of a straight mineral, residual lubricant of about 1000 seconds Saybolt viscosity at 210 degrees Fahr. Such a product will adhere tenaciously to the gear teeth and overcome vibration and wear. This same lubricant should also be used on chain drives. On the other hand, where gears and chains are enclosed in oil-tight housings, a somewhat lighter lubricant can be used to advantage, with the possibility of reduction in drag and power consumption. The pour test of such lubricants must be considered, for the probability of low temperature service above ground will always prevail. Obviously, a gear lubricant should be capable of following the gear teeth readily, otherwise its very purpose may be defeated if abnormal wear results. The degree to which satisfactory performance can be predicted is indicated by the pour test and relative change in viscosity with change in temperature.

ORE DRESSING

Metalliferous ores are generally treated or dressed in order to concentrate their mineral content prior to smelting and refining. As the ores of the non-ferrous base metals are mined, they are found to be blended with silicates or rock formations, or they occur in chemical combination with other elements, usually sulfur or oxygen.



Courtesy of Ingersoll-Rand Company

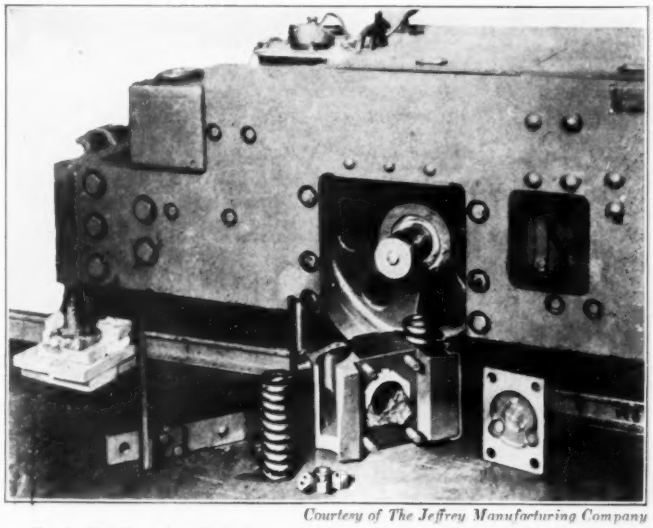
Fig. 6—Details of the Ingersoll-Rand double drum electric tugger hoist. Note extensive use of ball bearings, and fully enclosed gear cases.

The rock structure must be broken down by means of crushing and grinding in order to liberate the valuable mineral constituent from the gangue which is worthless. Then follows

classification for separating the finely crushed ore in the mill discharge from the coarser particles. The fine product or classifier overflow is next concentrated by gravity or flotation concentration, and the coarse portion returned to the grinding mill for regrinding until it finally reaches such a state of subdivision that it overflows the classifier.

The concentrating operation yields two products—a valueless rock tailing which is rejected to waste, and a valuable concentrate containing the greater part of the metal content in highly concentrated form. This concentrate is subjected to heat treatment in the smelter and emerges as the base metal, although not entirely pure. This smelter product then is sent to the refinery, the product of which is the pure metal containing generally an almost infinitesimal percentage of impurities.

Ore crushing is done by the jaw crusher, the gyratory, the roll or the cone type crusher; grinding is done in the rod or ball mill.

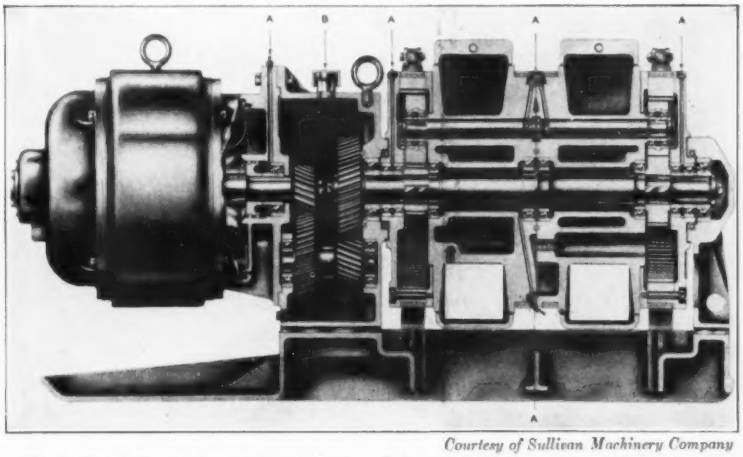


Courtesy of The Jeffrey Manufacturing Company

Fig. 8—Details and method of removing journal box on a Jeffrey inside wheel type of mine locomotive.

Jaw Crushing

The jaw crusher is usually a primary breaker, used for the first reduction in size of the ore as it comes from the mine. The basic principle of operation involves a pair of steel jaws which converge at an angle with respect to one another. The frame which forms one of these elements is fixed; the other is a swing jaw which rocks backward and forward to reduce the space at the apex of the angle and crush the ore as it works its way down between the jaws.



Courtesy of Sullivan Machinery Company

Fig. 7—The Sullivan two-drum scraper hauler. Points "A" indicate grease cup fittings for pressure grease lubrication to the ball bearings. At "B" transmission lubricant is applied to the gears.

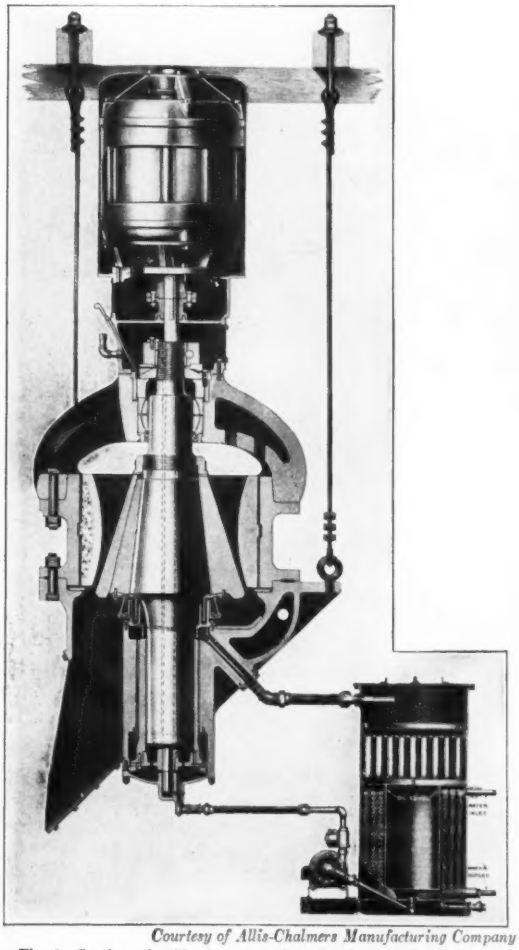
High back pressures are developed during this operation. They are carried by the toggle and pitman bearings which are of the water-cooled sleeve type. Obviously, they require very careful lubrication, so grease seals are often provided to prevent contamination and leakage.

The pitman bearing carries the pitman or that heavy steel casting which oscillates with its bearing as the point of suspension. Pressure grease lubrication is widely employed, although reservoirs in the bearing caps equipped with wool waste may also be employed. This waste can be saturated with lubricant or a special wool yarn grease can be used.

Lubrication of the eccentric bearings must also be carefully controlled, due to the potential loads which may have to be carried. Unless the weight of the pitman is more or less balanced by springs, etc., its weight will be exerted upon the eccentric shaft bearings, with the probable result that the lubricant will be unable to penetrate and maintain the requisite friction-reducing film between the shaft and bearings.

The construction of the crusher must, therefore, always be taken into consideration; where springs and links are used to balance the pitman, reservoir pad lubrication using a light grease will probably work out satisfactorily. Where

the weight of the pitman is carried on the eccentric bearings, as well as on its own supports, pressure lubrication with a heavier grease will be more positive. Constant pressure on the grease is a distinct adjunct to effective lubrication in such service.



Courtesy of Allis-Chalmers Manufacturing Company

Fig. 9—Section of a Newhouse crusher showing details of the positive oiling system which insures continuous circulation of clean, cool oil.

Toggle seats may or may not require lubrication, all according to the nature of their construction. Where rolling motion prevails, it is claimed that the need for lubrication is eliminated. Certain types, however, will involve sliding friction at the toggle seats. In such cases, oil lubrication is usually provided for by the builders by means of suitable drip cups. For this purpose a relatively heavy machine oil will serve the purpose.

In the Gyratory

The eccentric develops the necessary gyratory motion for the main shaft. This must be maintained at a uniform rate in the interest of maximum crushing ability with minimum power consumption. Lubrication, therefore, must be most carefully studied. As the eccentric revolves within a bushing and about a shaft, there are two surfaces to be lubricated. In addition, there is the brass wearing ring which carries the weight of the bevel gear and eccentric. In some machines, the base of the machine is also designed to fit loosely in the eccentric to facilitate tipping from side to side. This action may lead to serious overheating and wear unless adequate lubrication is maintained, for all the pressure will be periodically imposed upon a comparatively small area near the top of the thickest part of the eccentric sleeve.

Oil is delivered under positive and constant pressure to these mechanisms. Flood lubrication of this type is distinctly advantageous, for not only does the oil aid in removal of heat, but the pressure under which it is circulated also tends to somewhat counteract the mechanical pressure, developed on the wearing surfaces when the machine is in operation.

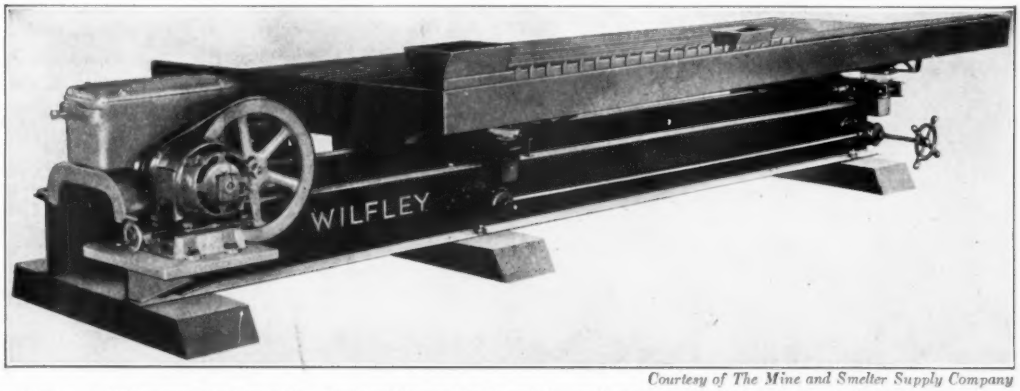
Oil circulation is maintained by means of a suitable oil pump located at the bottom of the crusher, either within or adjacent to the oil reservoir or chamber in the bottom plate. An ample supply of oil is contained in the system, which, as a rule, includes a suitable filter or strainer through which the oil passes at each circulation. This, together with the general dust-proof construction of the modern gyratory, insures against the entry and circulation of an excess of dust through the system. As a result, all the lower wearing parts are served with a flood of clean, cool oil throughout the period of operation of the gyratory crusher, for, by virtue of the nature of the design and construction, the oil pump starts simultaneously with the latter, operating at a speed commensurate with the rate of crushing.

Outboard bearings steady the shaft and take a great deal of load off the main bearing. A heavy engine or machine oil with a viscosity range of from 500 to 750 seconds Saybolt at 100 degrees Fahr., will usually prove successful in the average counter-shaft bearing of a gyratory crusher.

Wherever gears are involved, they are subjected to very hard service. For this reason dust rings are fitted about the shaft where it enters the gear case and all openings are covered, but despite all these precautions a certain amount of dust will find its way into the gear case to contaminate the gear lubricant.

This latter, therefore, must not be too thin or too low in viscosity, for then the film developed on the gear teeth will not have sufficient body to prevent grit from coming into

actual contact with the gear teeth as they pass into mesh. This, of course, would lead to abrasion and wear. As a result, the lubricant used upon these gears should be carefully selected. A straight mineral oil within the S.A.E.-140 range will usually function satisfactorily. It will furthermore resist the drying action of the dust and prevent its packing between the teeth of the gears, thus obviating any tendency in the latter to spring and throw unnecessary pressure upon the countershaft bearings and the eccentric. Where a crusher may have to operate in cold weather, the lubricant used upon the gears must also have a low pour test to insure proper fluidity of the oil. This will reduce drag, power consumption and the possibility of abnormal wear of the gear teeth.



Courtesy of The Mine and Smelter Supply Company

Fig. 10—A Wilfley concentrating table. Considerable provision is made for positive and automatic lubrication of this device.

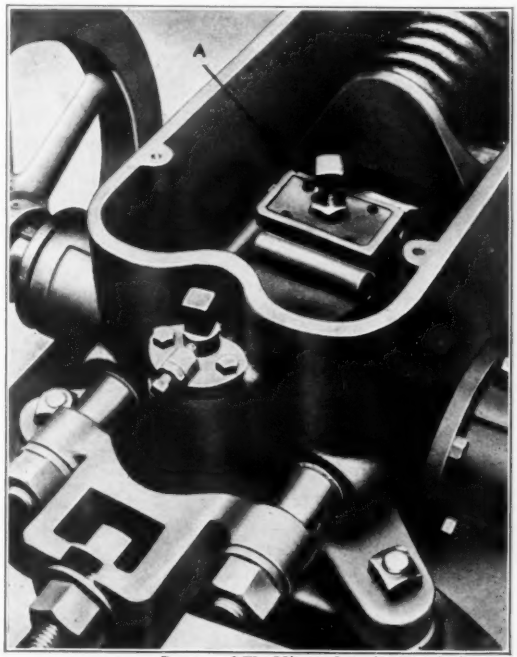
Rod and Ball Mill Bearings

The rod, tube or ball mill is used for secondary crushing, usually in conjunction with the classifier. Since rotary motion is involved, lubrication of such equipment is confined to the trunion bearings which carry the mill drum journals. This often becomes a problem due to

1. The heavy loads which must be carried.
2. The possibility of overheating.
3. Water or dust contamination.

So it is customary to use a medium to heavy-bodied oil or grease (according to the type of lubricating system) to avail of not only the lubricating, but also the sealing benefits. Water cooling is also provided by some builders. This offsets the heat problem to some extent.

Bearings of this type are of comparatively large size. Furthermore, as all the thrust is downward, due to the weight of the mill and its contents, certain types of these bearings are very often lined on the bottom half only; this lining can readily be replaced when worn. Inasmuch as the caps of such bearings carry no lining, they merely serve as dust shields and receptacles for the grease used in their lubrication. Care should always be taken to see that this latter is a carefully refined fibrous grease of high melting point. Where wool yarn packing is desired, however, a lighter grease, or a high grade crusher oil, should be used as the medium for saturation. The wool yarn serves as a seal or strainer to catch dust or dirt.

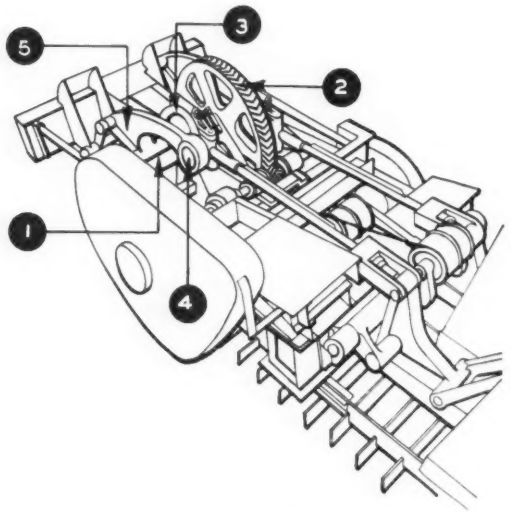


Courtesy of The Mine and Smelter Supply Company

Fig. 11—Head motion of a Wilfley table showing pitman lubrication holes at "A". All moving parts of this motion are splash lubricated by oil from the reservoir in the bottom of the housing.

CLASSIFICATION

The rod, tube or ball mill is almost invariably operated in closed circuit with a classifier. The discharge from the mill is classified or sized in this unit so that only the finest constituent overflows from the classifier to the next process-



Courtesy of The Dorr Company, Inc.

Fig. 12—Lubrication diagram for the head motion on a Dorr FX Classifier. "1" is the main shaft; "2" the main gear; "3" the eccentric bearings of ball type; "4" the self-aligning roller bearing crankpin bearings; "5" the connecting rod and linkage parts. Centralized pressure grease lubrication is employed on this machine.

ing step, while the coarser portion of the mill discharge is discharged by the classifier and returned to the feed end of the ball mill for further grinding. Separation in the classifier is made hydraulically, the principle being that the rate at which the ore particles settle in the classifier is a function of their size—the smaller the particle, the slower the rate, and the larger the particle, the greater the rate.

From a lubrication viewpoint, the classifier is one of the most important mechanisms in the smelter. It is heavy, rugged and durable, built to handle large tonnage by the mechanical action of rakes or spiral blades which aid in separating the coarse material (or sand) from the fines (or pulp). Classifier operation requires a head motion involving an eccentric to draw the rake blades along an inclined deck (to move the sand) and then to lift and return them for another bite.

So the classifier is equipped with heavy duty bronze bushings to carry the main shaft, and ball and roller bearings for the eccentric and crankpins. Most modern construction plans for centralized pressure grease lubrication of all bearings on the classifier. All are located above the pulp level to preclude lubricant contamination and wear. The gears are also tightly housed for the same purpose. Being of the herringbone type, they are lubricated by a high grade straight mineral oil ranging from 300 to 800 seconds Saybolt Universal Viscosity, according to temperature conditions.

IN THE SMELTER

Whereas the lubrication engineer is dealing with a water condition in the selection of lubricants for most of the modern ore dressing machinery, when he comes to the smelter he has excessive heat to consider. Here the concentrated ores are converted from mineral combinations to more or less pure metal.

General procedure is to roast the ore to drive off most of the sulfur. This may be accomplished in a roasting furnace, followed by melting in a blast furnace, retort or reverberatory furnace, according to the type of metals to be recovered. The reverberatory and converter are widely used where copper predominates; the roaster or sintering furnace where zinc is chiefly involved, and the blast furnace where lead is smelted.

Lubrication becomes of importance in the operation and maintenance of certain of the furnace charging machinery and the rotating casting machines which take the hot metal discharge from the reverberatory furnace. All metals must obviously be poured at their melting point temperature. The maximum prevails with copper, viz., around 2000 degrees Fahr.

The operating mechanism of the casting machine is so close to the hot metal that the radiated heat and fumes surrounding the working parts are extreme during the entire course of operation. Lubrication under such consistently high temperature conditions is always a problem. It can only be successfully maintained by coordination of the means of application with the heat-resisting qualities of the lubricant.

All this has been anticipated by the builders of the machinery, to the end that the necessary gear mechanisms are carefully housed and the bearings likewise protected to prevent undue leakage of their lubricants.

In the selection of oils and greases for such service, the viscosity and flash points of the oils and the melting points of greases must be watched. Normally, the viscosity or body will be indicative of the temperature-resisting ability of an oil. Of necessity, it must be comparatively high. This is why heavy bodied oils are so widely preferred. Furthermore, they possess high flash points, so their vaporizing tendency is low. Such oils can be used alone, as for example, to lubricate ball or roller bearings, or enclosed gear sets, or they may be compounded in the manufacture of high temperature greases.

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IN THE MINE

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Compressor Cylinders	TEXACO Cetus or Alcaid Oils
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(grease lubricated)	TEXACO Cup Greases
Mine car wheel bearings (according to type)	TEXACO Olympian Mine Car Greases or TEXACO Bearing Oils
Locomotive Bearings	TEXACO Star Greases or TEXACO Marfaks
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Gears (enclosed)	TEXACO Thubans
(exposed)	TEXACO Crater Compounds

IN THE MILL AND SMELTER

ORE CRUSHING	
Jaw Crusher-Pitman and eccentric bearings	TEXACO Pelican Oil or TEXACO Bearing Oils
Grease lubricated	TEXACO Marfaks or TEXACO Star Greases
Gyratories (oil lubricated) (according to type)	TEXACO Algol or Ursa Oils, TEXACO Pelican Oil, TEXACO Crusher Oil or TEXACO Bearing Oils
(Grease lubricated)	TEXACO Star Greases or TEXACO Marfaks
Roll Crushers, Ball and Rod Mills	
Bearings (oil lubricated)	TEXACO Aleph, Altair or Aries Oils
(grease lubricated)	TEXACO Marfaks or TEXACO Star Greases
ORE DRESSING AND CLASSIFICATION	
Bearings (oil lubricated)	TEXACO Aleph, Altair or Nabob Oils
(grease lubricated)	TEXACO Star Greases
Gearing	
enclosed—normal temperatures	TEXACO Ursa Oils
low temperatures	TEXACO Alcaid or Algol Oils
exposed	TEXACO Crater Compounds
CASTING MACHINERY AND CONVEYORS	
Bearings (oil lubricated)	TEXACO Aries or Arcturus Oils
(grease lubricated)	TEXACO Marfaks
Gearing and chains	TEXACO Crater Compounds

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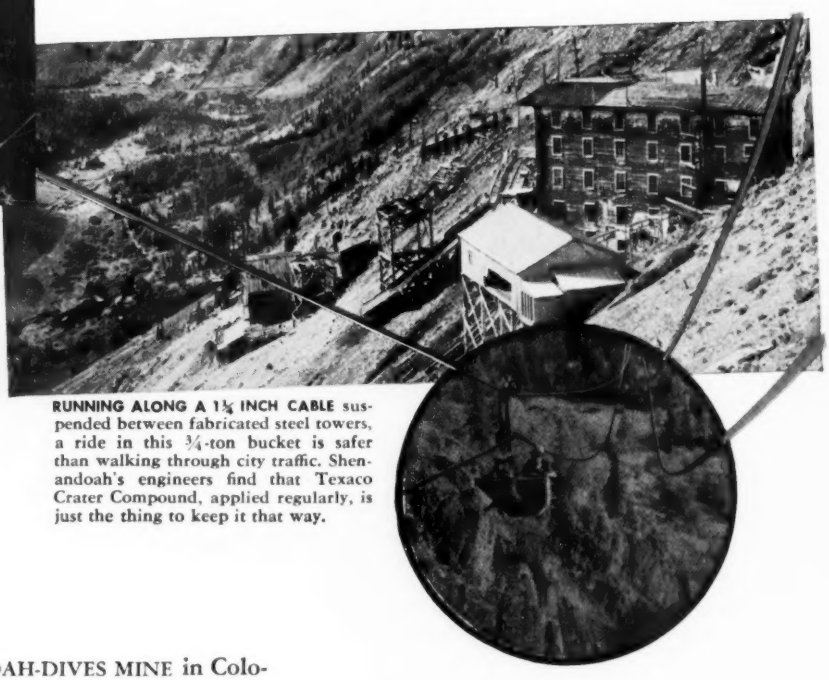
(*Above*) **LIKE MANY HIGH-ALTITUDE MINES,** the Shenandoah-Dives Mine near Silverton, Colorado, relies upon aerial tramways for all transportation between operating units. The 10,000-foot tramway shown here has a total rise of 1,520 feet from the mill buildings at the base of the cliff up to the mine. Every foot of the cable is lubricated regularly with Texaco Crater Compound A.



RUNNING ALONG A 1⅛ INCH CABLE suspended between fabricated steel towers, a ride in this ¾-ton bucket is safer than walking through city traffic. Shenandoah's engineers find that Texaco Crater Compound, applied regularly, is just the thing to keep it that way.

SHENANDOAH-DIVES MINE in Colorado handles this amount of material. Their maintenance engineers say this:

"It is important that the tram cable be lubricated to the core, with a lubricant that will insure protection against corrosion from the elements, and of sufficient body and other characteristics to insure adhesion to the cable in all kinds of weather. It has been our experience that Texaco Crater Compound 'A' is a suitable lubricant for these cables."

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